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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A23L 3/3418, 3/3427, A23B 7/148 | A1

(11) International Publication Number: WO 95/05753

(43) International Publication Date: 2 March 1995 (02.03.95)

(21) International Application Number: PCT/GB94/01825

(22) International Filing Date: 19 August 1994 (19.08.94)

(30) Priority Data:
9317523.0 21 August 1993 (21.08.93) GB

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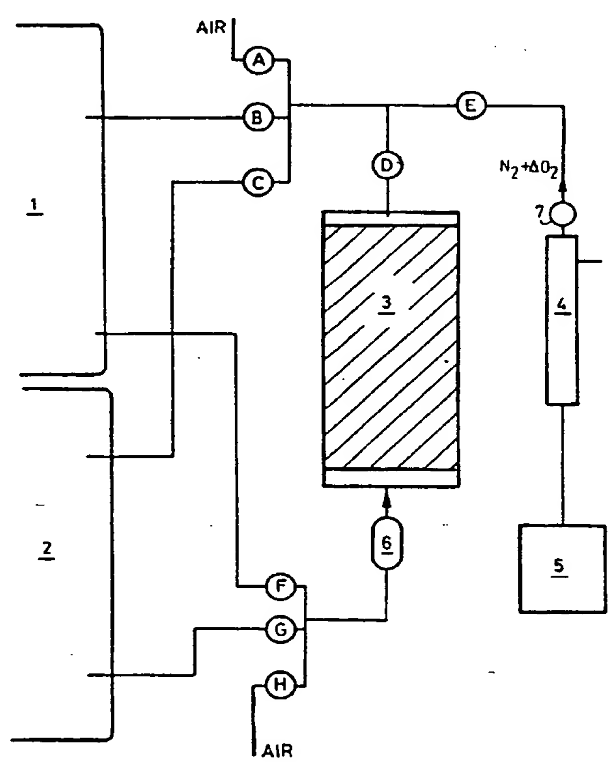
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD).

Published
With international search report.

(54) Title: CONTROL OF THE ATMOSPHERE IN PRODUCE STORAGE ROOMS

(57) Abstract

A system for controlling the atmosphere in a produce storage room (1), in which a nitrogen source (4) is used for initially purging the room, a carbon adsorption bed (3) is used for adsorbing carbon dioxide in the room atmosphere when circulated through the bed, thereby to control the carbon dioxide content of the atmosphere, after regeneration of the bed to desorb carbon dioxide the bed is purged of oxygen with nitrogen from the source, and this purging step is manipulated to control the oxygen content of the room atmosphere.



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Title: Control of the Atmosphere in Produce Storage Rooms

Field of the invention

This invention relates to a method and apparatus for establishing and maintaining a required atmosphere within fruit, vegetable and produce storage rooms or other chambers or environments for storing such goods. For convenience, these are referred to herein as produce storage rooms.

Background to the invention

Fruit, vegetables and other produce such as nuts and grains can be stored to advantage in atmospheres other than ambient air (which has the composition 21 per cent O_2, .03 per cent CO_2, 79 per cent N_2).

The predominant use of this method is to prolong storage life from a few weeks to over twelve months, depending upon the produce, variety and cultivar. This method is almost invariably used in conjunction with refrigeration to maintain a temperature most suited to the produce.

Typically, Delicious apples can be stored at 0 degrees C and in an atmosphere having an oxygen concentration of 1.5 per cent and carbon dioxide at 3 per cent for up to ten months. Bananas, on the other hand, can be stored at 3 per cent oxygen, 5 per cent carbon dioxide, at a temperature of 14 degrees C for a period of three months.

After harvest, the produce is placed in a refrigerated storage room which is carefully sealed to prevent or minimise leakage of air either in or out. Under these conditions, the produce will continue to respire, consuming oxygen and producing carbon dioxide. In order to maintain the correct storage conditions, it is necessary to remove the carbon dioxide produced without causing the oxygen concentration to increase. It is also often of advantage to reduce the oxygen concentration more quickly than that achieved by natural respiration. However, it may also be necessary to allow some oxygen in the form of fresh air to enter to ensure the correct oxygen level is maintained.

Carbon dioxide is conventionally removed by one of three alternative methods. Hydrated lime ($Ca(OH)_2$) can be used to absorb the carbon dioxide by an irreversible chemical action, after which the lime is discarded. The cost and inconvenience of this system makes this unattractive to many users.

Nitrogen or nitrogen containing a small amount of oxygen can be used to flush out the carbon dioxide produced, by purging on a continuous or intermittent basis. The flow rate of the nitrogen is dependent upon the required carbon dioxide content and the respiration rate of the produce. In general, the energy required to produce sufficient nitrogen rapidly increases as CO_2 levels reduce and the respiration rate increases.

The third known method of CO_2 removal is a mechanically activated carbon adsorber. The storeroom atmosphere is passed through a bed containing activated carbon, which

adsorbs the carbon dioxide, returning the remainder of the atmosphere to the storage room. When the carbon is saturated, the bed is disconnected from the storeroom and flushed with air, the CO_2 being desorbed into the air stream. When all this is complete the adsorption phase is repeated. The carbon adsorber is energy-efficient in removing CO_2 but a problem arises in preventing the flushing air from entering back into the storage room, causing an increase in oxygen above the required value. There are various known methods and devices using sequencing, pressure vessels and vacuum to overcome this problem of flushing air entering the storage atmosphere.

For rapid establishment of the storage atmosphere, it is common to flush the room with nitrogen or a nitrogen, low oxygen mixture. This can be achieved by using liquid nitrogen supplied by tanker, or by use of mechanically produced nitrogen using membrane or pressure swing adsorption technology. The flow rate is controlled at a suitable level for the room atmosphere to reach the value required in the desired time.

Unless the storage room is excessively leaky, it is also necessary to allow a small amount of air to enter the room to replace the oxygen consumed by respiration. This is done on either a continuous or intermittent basis and the process is often under automatic control.

The present invention aims to provide method and apparatus which combines all the functions required to control a produce storeroom atmosphere, operating together preferably under electronic control in order to obtain maximum energy efficiency of the operation.

The invention

According to one aspect of the invention, there is provided a method of controlling the atmosphere of at least one produce storage room, including the repetitive steps of: a) controlling the carbon dioxide content of the room atmosphere by cycling the atmosphere through a carbon adsorption bed; b) regenerating the bed by passage of fresh air; and c) purging the bed of oxygen by passage of nitrogen from a nitrogen source, wherein when necessary the oxygen content of the room atmosphere is at least in part controlled by omission or variation of the period of step c).

According to a second aspect of the invention, there is provided apparatus for controlling the atmosphere of at least one produce storage room, comprising a carbon adsorption bed, a nitrogen source and valved pipework connecting the adsorption bed and the nitrogen source with each other and with the room, wherein common valves are utilised to control repetitive operations of the adsorption bed and the nitrogen source in order to control both the oxygen content and the carbon dioxide content of the room atmosphere.

Moreover, according to a third aspect of the invention, there is provided apparaus for controlling the atmosphere of at least one produce storage room, comprising a carbon adsorption bed and a nitrogen source and valved pipework connecting the adsorption bed and the nitrogen source with each other and with the room, wherein the nitrogen source constitutes a sole means for removing oxygen from the adsorption bed.

Although referred to herein as a source of nitrogen, it will be understood that in practice the source may provide a nitrogen-rich gas with very low oxygen content.

Thus, the apparatus comprises an adsorption bed for carbon dioxide removal, a nitrogen source which is used for initial establishment of conditions and for purging the carbon bed from excess air. The oxygen needed to support respiration is provided by omitting the nitrogen purge of the carbon bed, when required.

The system in accordance with the invention considerably reduces the energy consumption of purge only systems, overcomes the problems of air removal from the carbon bed, and improves efficiency by providing oxygen by reducing purge rather than adding air.

Description of embodiment

One embodiment of the invention is shown schematically in the accompanying drawing. Two fruit stores 1 and 2 are shown. These are typically sealed refrigerated rooms with capacities varying from 10 to 1,000 tonnes of produce. Although two are shown, the invention can be practised for a single room or for a multiple number, in practice probably not exceeding ten.

A carbon adsorption bed 3 forming part of the system will vary in size depending upon the size and number of the storage rooms. This bed 3 typically contains steam-activated extruded carbon pellets, Norit R2030 (Trade Mark) being a carbon commonly used in this field. The carbon bed is connected to each room with piping or tubing through on/off valves, shown in the drawing and

respectively designated A to H. The circulation of the room atmosphere through the bed 3 is driven by a fan 6.

Nitrogen with a small amount of oxygen is conveniently produced by a source 4 which comprises a semi-permeable membrane contained in a housing. Such sources are commercially available and widely used throughout industry. The membrane is supplied with compressed air at typically eleven bar pressure from an air compressor 5.

The oxygen concentration of the gas stream output from the source 4 depends upon the output flow rate, which is adjustable by a control valve 7. The output flow of the nitrogen is switchable on or off by a solenoid valve E. The compressor 5 is automatically switched on demand by a pressure switch (not shown).

In operation, the sequence of operating steps is as follows:-

a) Produce is loaded into the storage room 1. The temperature is reduced and doors and hatches are sealed.

b) Valves B, F, H and E are opened to allow nitrogen with oxygen in low concentration to flow from the membrane 4 into the room, through valves E and B, purging out the atmospheric oxygen through valves F and H to exhaust. This step is continued until the room oxygen is considered to be reduced to the level required, at which time all the relevant valves are shut.

c) No further operations then occur until the respiration of the produce in room 1 increases the carbon

dioxide content to the desired level.

d) When the carbon dioxide in room 1 becomes higher than required, the carbon bed 3 is prepared for operation. Nitrogen from the membrane 4 is purged through the bed 3 by opening valves E, D and H. This continues for a time sufficient for the majority of the oxygen to be removed from the carbon bed 3. The relevant valves are then closed.

e) When the purge process is finished, a scrubbing cycle commences by opening valves B, D and F and starting the operation of fan 6. The atmosphere from the storage room 1 is then drawn through valve F into the carbon bed 3 and returned to the room through valves D and B. This operation continues until the carbon in the bed is saturated with carbon dioxide.

f) When the carbon is saturated it is regenerated by de-adsorbing the carbon dioxide into fresh air. The store valves B and F are closed, with valves A and H opening, valve D remaining open and the fan 6 remaining on. Fresh air is then passed through the carbon bed 3, through the valve H and exhausted through the valves D and A. This step continues for a time sufficient for the carbon dioxide to be removed from the bed 3, after which the fan 6 stops and the relevant valves shut.

g) The system then remains idle until or unless more CO_2 requires removal from the room. When further CO_2 removal is called for, the sequence starts again with step (d).

h) When it has been determined that the oxygen in the room has fallen to a lower value than required, then the

bed purge process described in step (d) is omitted and scrubbing step (e) is allowed to continue to permit some oxygen entry into the room. Alternatively, a reduced purge time for step (d) will control the amount of oxygen returning to the room.

i) If, due to leakage of air into the room, the oxygen increases above an acceptable level, then the nitrogen purge sequence described in (b) can be repeated to reduce the oxygen level to the required value.

The method for room 2 is analogous.

Operating steps a) to i) are preferably automated and performed under electronic control.

Claims

1. A method of controlling the atmosphere of at least one produce storage room, including the repetitive steps of: a) controlling the carbon dioxide content of the room atmosphere by cycling the atmosphere through a carbon adsorption bed; b) regenerating the bed by passage of fresh air; and c) purging the bed of oxygen by passage of nitrogen from a nitrogen source, wherein when necessary the oxygen content of the room atmosphere is at least in part controlled by omission or variation of the period of step c).

2. A method according to claim 1, wherein the required atmosphere in the room is initially produced by purging out atmospheric oxygen by use of the nitrogen source.

3. A method according to claim 2, wherein when necessary the repetitive cycle of steps is interrupted to repeat the room atmosphere oxygen purging step to compensate for leakage of air into the room.

4. Apparatus for controlling the atmosphere of at least one produce storage room, comprising a carbon adsorption bed, a nitrogen source and valved pipework connecting the adsorption bed and the nitrogen source with each other and with the room, wherein common valves are utilised to control repetitive operations of the adsorption bed and the nitrogen source in order to control both the oxygen

content and the carbon dioxide content of the room atmosphere.

5. Apparatus according to claim 4, having common valves opened both to pass through the adsorption bed to exhaust air used for regeneration of the bed and nitrogen used to purge the storage room.

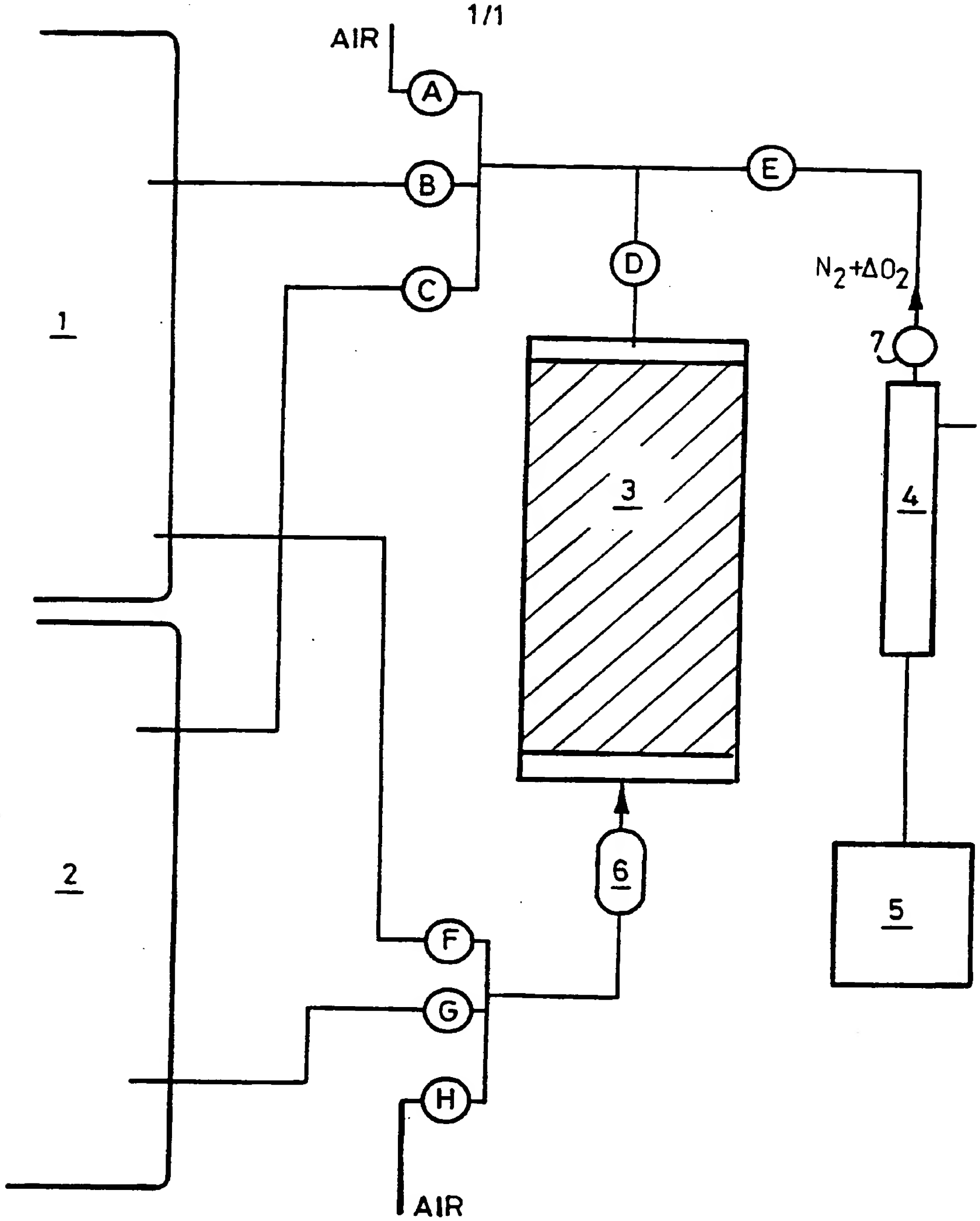
6. Apparatus according to claim 4 or claim 5, having a common valve opened to admit nitrogen to the room initially to purge the atmosphere of oxygen and subsequently to cycle the room atmosphere through the adsorption bed.

7. Apparatus according to claim 4 or claim 5 or claim 6, having a common fan operable during regeneration of the adsorption bed and during cycling of the room atmosphere through the bed.

8. Apparatus for controlling the atmosphere of at least one produce storage room, comprising a carbon adsorption bed and a nitrogen source and valved pipework connecting the adsorption bed and the nitrogen source with each other and with the room, wherein the nitrogen source constitutes a sole means for removing oxygen from the adsorption bed.

9. A method of controlling the atmosphere of at least one produce storage room substantially as hereinbefore described.

10. Apparatus for controlling the atmosphere of at least one produce storage room substantially as hereinbefore described with reference to the accompanying drawing.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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/01825

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A23L3/3418 A23L3/3427 A23B7/148

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A23L A23B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	EP,A,0 565 827 (ISOLCELL ITALIA) 20 October 1993 see column 6, line 9-18; figures 4,1; example see column 4, line 13-19	1,2,4-6, 8-10
A	EP,A,0 363 553 (ISOLCELL ITALIA) 18 April 1990	
A	VOEDINGSMIDDELEN TECHNOLOGIE, vol.18, no.8, April 1985, ZEIST NL pages 69 - 75 L BAKKER ET AL. 'DE TECHNIEK VAN DE CA-BEWARING VAN TUINBOUWPRODUKTEN' see page 71, column 1, paragraph 4 - page 71, column 2, paragraph 1; figures 6,7	1
A	DE,A,29 22 145 (INTERCELL) 20 March 1980	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR,A,2 523 472 (SAMIFI BABCOCK) 23 September 1983	
A	EP,A,0 136 042 (THE SHIPPING CORP. OF NEW ZEALAND) 3 April 1985	
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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